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SCOTT AVIATION LANCASTER NY

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LOW AIR RESISTANCE CANISTER. PARALLEL PLEATED HEPA FILTER.(U)

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LOW AIR RESISTANCE CANISTER

Parallel Pleated HEPA Filter

Scott Aviation, A Figgie International Company  
225 Erie Street  
Lancaster, New York 14086

July 1, 1982

FINAL REPORT

Prepared for

Naval Research Laboratory  
4555 Overlook Avenue, S.W.  
Washington, D.C. 20375

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## SUMMARY

A parallel pleated HEPA filter has been developed to reduce the pressure drop across the Navy ND-C-1 filter by increasing the surface area in a minimal amount of space. The pressure drop was reduced by 594 percent due to an increase in the effective surface area of 677 percent. Spacing of the pleats was accomplished by dispensing adhesive and thread simultaneously on the surface of the filter media. This produced a spacing of 4.07 pleats per cm with a height of 0.91 cm.

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## INTRODUCTION

The canister presently used on the Navy Mark V gas mask is designated ND-C-1. This canister contains a flat disc of particulate filter media. One method to reduce the pressure drop across this filter is to increase the effective surface of the media area. This can be accomplished without increasing the diameter of the canister by pleating the filter media but it will increase the depth of the present canister equivalent to the height of the pleat. A method for cutting the circular configuration and encapsulation of the filter in the canister was developed at the Scott Aviation Plant #1 test laboratory.

## MATERIALS

Filter media - Lydall Grade L-255 HEPA glass filter media, QPL-51079-1

July 30, 1981, qualified under MIL-F-51079.

Weight	90 g/M <sup>2</sup>
Caliper	.43 mm
Tensile, MD	1.15 KN/M
Tensile, CD	.77 KN/M
Elongation	1.5%
Pressure Drop @ 32 LPM/100 cm <sup>2</sup>	36 mm H <sub>2</sub> O
DOP Penetration @ 32 LPM/100 cm <sup>2</sup>	.015%
Water Repellency	760 mm
Ignition Loss	5.0%
Yield	11.1 M <sup>2</sup> /kg

Thread - Neophil K-207 unbonded soft white nylon.

Adhesive (thread) - Borden Cascomelt HC-6286 heat sealable hot melt adhesive.

Type - thermoplastic solid

F & DA Status - none

Odor - mild at 176°C

Flamability - will char with overheating

Encapsulating media - Silicone Adhesive/Sealant

Corrosion properties - none

Temperature range - 65°C to 182°C for extended periods.

Color - white

Durometer Hardness - Shore A, 25 points

Elongation - 400%

Meets FDA Regulation No. 21 CFR177.2600

Meets NSF Criteria C2 for direct contact with food

UL approved for service to 180°C

Usage - 10 parts of #738 RTV to 3 parts of Trichloroethane 111 by weight.



## EQUIPMENT

### Pleating Machine

The experimental pleating was performed on a modified Rabo 68 Accordion Pleating Machine. This machine has top and bottom reciprocating blades which alternately fold the media in pleats against each other by retracting from the previous fold upward or downward, extending the folding edge outward, advancing upward or downward against the web of media and returning to a vertical position against the other blade. This folded material is then ejected out of the blade area in a continuous stream of pleats. The only adjustment provided on this machine is for pleat height.

### String and Adhesive Applicator

The equipment used for this application was a Meltex model CR-05 Hot melt adhesive dispenser with 2 thermostatically controlled hoses and 2 each of eleven nozzle manifolds, one for the upper side and one for the lower side.

### Encapsulating Machine

To seal the open ends of the circle of filter material and encapsulate it in the canister, a spinning machine was designed and built by Scott Aviation. The rotation was achieved by a Boston Ratiotrol Drive model VEL25D and a 1/4 HP DC motor with a range of 0-2200 RPM. The applicator disc is mounted on a vertical shaft with the liquid sealant reservoir in the up position. The canister and filter are inverted and clamped to the disc. The assembly is spun at 2100 rpm and the liquid sealant is dispersed up the inside wall of the canister and into the outer periphery of the pleats by centrifugal force.

### Pleat Cutter

A circular saw was designed to cut discs of pleated material from a block of preformed and glued pleats. The saw consists of a metal disc with a spindle, a blade and a soft spring loaded, non rotating pressure foot. The scalloped blade is approximately 0.5 millimeters thick, straight on the inside and beveled on the outer side to a sharp edge. The apex of the scallops are on approximately 13 millimeter centers. This blade was rotated at a speed of 1300 RPM with a one second feed.

### Filter Construction - Figure 1

Diameter of the pleated media - 7.62 cm.

Total number of effective pleats - 31.

Number of pleats per centimeter - 4.07

Distance between pleats - 0.245 cm.

Pleat height - .91 cm.

Using the formula  $L = 2 \sqrt{R^2 - d^2}$  to determine the length of the pleats where

L = pleat length to be determined

2 L = total pleat length since each pleat has 2 faces

R = radius of the circle of the pleated material

d = distance from the center line or diameter of the filter to each pleat  
in accumulative increments of 0.245 cm per pleat.

Pleats	d/cm	d/cm <sup>2</sup>	L/cm	2 L/cm
1	0.245	0.06	7.60	15.20
2	0.490	0.24	7.56	15.11
3	0.735	0.54	7.48	14.95
4	0.980	0.96	7.36	14.72
5	1.225	1.50	7.21	14.43
6	1.470	2.16	7.03	14.06
7	1.715	2.94	6.80	13.61
8	1.960	3.84	6.53	13.07
9	2.205	4.86	6.21	12.43
10	2.450	6.00	5.83	11.67
11	2.695	7.26	5.39	10.77
12	2.940	8.64	4.85	9.69
13	3.185	10.14	4.18	8.36
14	3.430	11.76	3.32	6.63
15	3.675	13.51	2.00	<u>4.00</u>

178.70 cm  
total length of pleats.



# PRESSURE DROP TEST

For a diagram of the apparatus used see Figure 2.

Test of 10 samples of parallel pleated filters 0.91 cm high and 7.62 cm in diameter.

$Q_s$  = Flow in liters per minute

$V_F$  = Face velocity in cm/second

$\Delta P$  = Pressure drop in millimeters of water

$Q_s$	$V_F$	1	2	3	4	5	6	7	8	9	10	AVERAGE	P
12.76	4.7	5.92	6.27	6.65	6.63	6.17	6.50	6.30	6.55	6.68	6.55	6.42	mm
24.03	8.8	10.46	11.05	11.76	11.61	10.77	11.38	11.00	11.81	11.81	11.56	11.32	mm
35.28	12.9	14.99	15.98	16.89	16.54	16.56	16.46	15.67	17.02	17.02	16.71	16.38	mm
46.00	16.8	19.81	21.13	22.61	22.07	20.35	21.72	20.80	22.35	22.53	22.10	21.55	mm
56.72	20.8	24.89	26.97	28.45	27.79	25.91	27.48	26.16	28.45	28.58	28.19	27.29	mm

Test of five (5) samples of a single flat disc of filter media 7.62 cm. in diameter. The flat disc represents a similar condition as found in the ND-C-1 canister

$Q_s$	$V_F$	1	2	3	4	5	AVERAGE	P
12.82	4.7	36.83	47.50	36.58	36.58	36.07	38.71	mm
24.14	8.8	64.26	82.55	65.02	63.25	62.48	67.51	mm
35.45	13.0	92.46	117.35	91.95	90.68	89.66	96.42	mm
46.22	16.9	121.16	154.94	121.67	120.14	118.62	127.31	mm
57.00	20.8	152.91	201.93	152.65	150.37	148.59	161.29	mm

For a graphic comparison see Figure 3.

$$\frac{P \text{ flat disc}}{P \text{ Parallel pleat}} = \text{Times reduced} = \% \text{ reduction using the parallel pleat}$$

$$1. \frac{38.71 \text{ mm}}{6.42 \text{ mm}} = 6.02 = 602\%$$

6.42 mm

$$2. \frac{67.51 \text{ mm}}{11.32 \text{ mm}} = 5.96 = 596\%$$

11.32 mm

$$3. \frac{96.42 \text{ mm}}{16.38 \text{ mm}} = 5.89 = 589\%$$

16.38 mm

$$4. \frac{127.31 \text{ mm}}{21.55 \text{ mm}} = 5.91 = 591\%$$

21.55 mm

$$5. \frac{161.29 \text{ mm}}{27.29 \text{ mm}} = 5.91 = 591\%$$

27.29 mm

$$602\% + 596\% + 589\% + 591\% + 591\% = 2969\%$$

2969% = 594% average decrease in pressure drop using the parallel parallel

5 pleated filter.

# DOP PENETRATION

Test equipment - ATI Penetrometer model Q127, S/N 4064.

Parallel pleated filters tested at a flow rate of 32 SLPM.

## % Penetration

1.	.068	6.	.001
2.	.020	7.	.001
3.	.019	8.	.580
4.	.009	9.	.160
5.	.320	10.	.001

Flat filter at a flow of 32 SLPM

## % Penetration

1. .015
2. .019
3. .010
4. .007
5. .009

## CONCLUSION

1. The following datum was developed during the completion of this project:
  1. A parallel pleated filter can be manufactured to replace a flat filter with the same diameter and thereby reduce the pressure drop by a considerable amount. For a 0.91 cm high pleat this reduction averaged 594%.
  2. The depth of a canister with a flat filter must be increased an amount equal to the pleat height to utilize a parallel pleated filter.
  3. A pleating machine would have to be developed to provide the means of applying the string and adhesive to both sides of the filter media.
  4. The higher DOP penetration readings are probably due to the upsetting of the fiberglass fibers while attaching the adhesive and string to the bottom side of the block of pleated material. It was necessary to install the string and adhesive on the bottom side by hand since the pleating machine used did not lend itself to this operation.



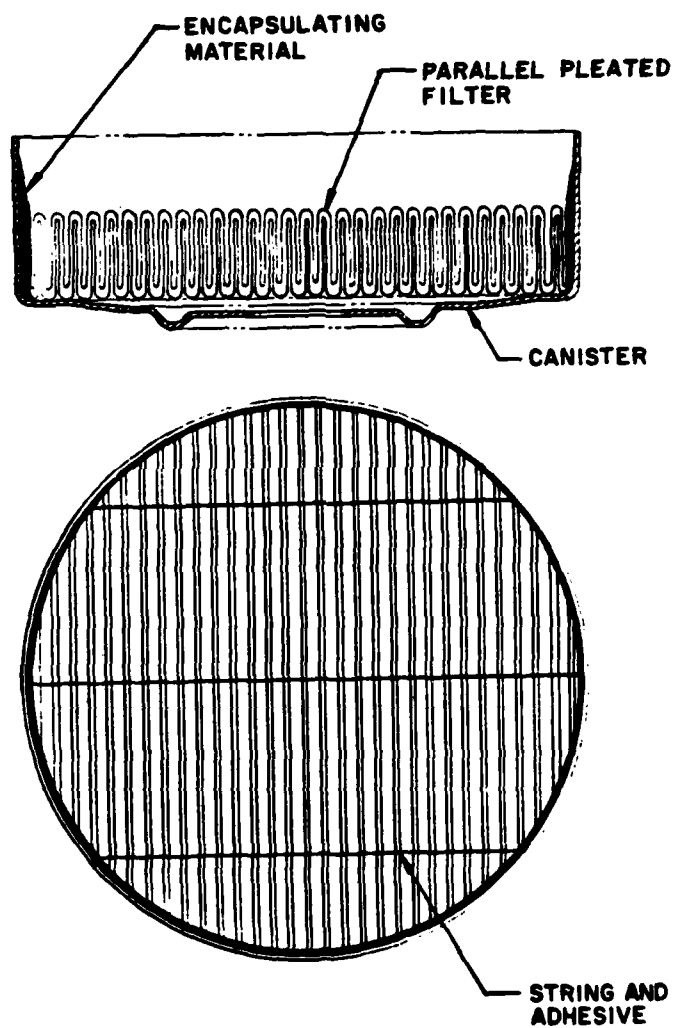


FIGURE 1 • FILTER ASSEMBLY

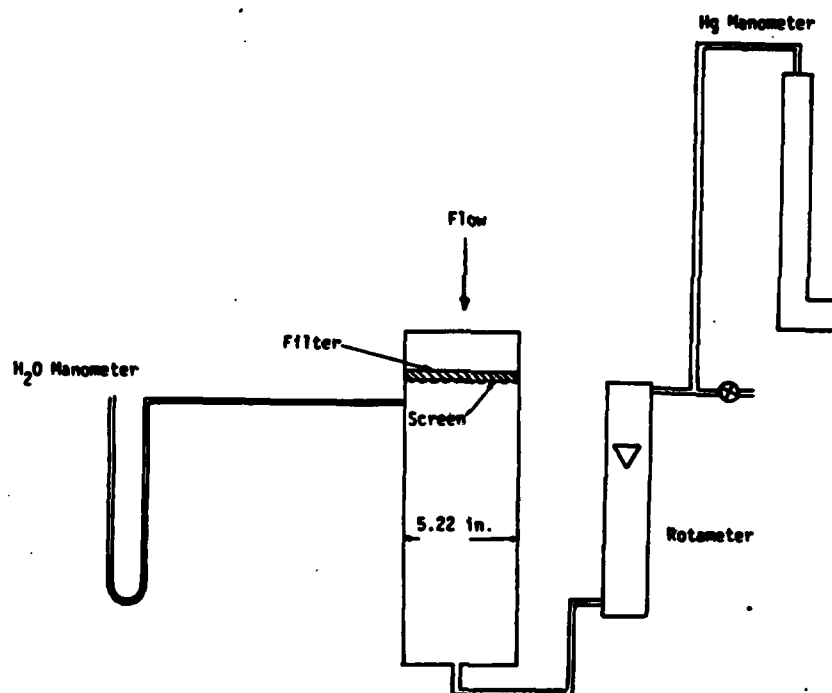


FIGURE 2=FILTER PRESSURE-DROP TESTING APPARATUS

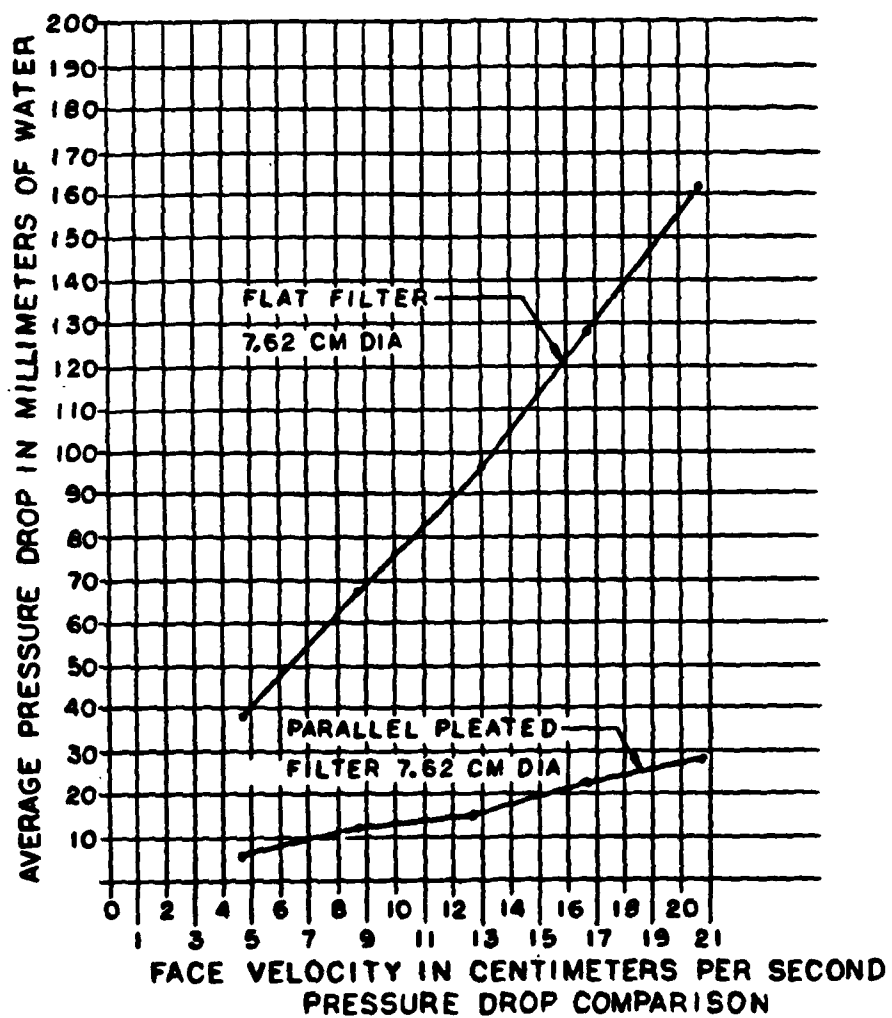


FIGURE 3